

frequencies of these binomials are termed "distortion constants", and these can be used to construct the frequency distribution of observed exchanges from any initial distribution of events. For example, starting with a Poisson distribution of events with mean = 2.0, each term is multiplied by the appropriate set of distortion constants, and the resultant distributions summed. Fig. 1 shows the result with and without distortion. Distortion results in a typical underdispersed ("binomial") distribution of exchanges.

In Fig. 2 this procedure has been repeated for a range of Poisson distributions, and the effects of distortion are shown as a plot of relative variance (that is variance/mean) against the final distribution mean. The line approximates closely to that expected for a binomial with index 4.0. The points shown are relative variances actually observed in *Campelia*, the data being taken from an X-ray dose-response curve of dicentric + centric ring exchanges. The agreement indicates that the "binomial" exchange distributions in this species can be fully accounted for in terms of distortion, and there is no need to place a limit upon the number of exchanges that can take place.

It is clear that the process of distortion leads to a progressive "loss" of exchanges as the number of events increases. This has two consequences. (a) The shape of the dose-response curve for dicentrics and rings is modified, and therefore parameters, such as the "coefficients of aberration production", derived from it are liable to be in error. It should be noted that this modification is operating to some extent even at low doses. Using the distortion constants, it is possible to obtain a plot of expected and observed mean exchange yields. The parameters of a curve fitted to this plot ("distortion coefficients") enable corrections to be made to dose-response curves, so that the "true" (undistorted) yields and parameters can be determined. (b) The increasing "loss" of exchanges with increasing radiation dose leads to eventual saturation of the dose-response curve.

There is no reason to assume that the process of distortion is confined to *Campelia*, and it may well account for other cases of non-random exchange distributions, and saturating dose-response curves.

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## GENERAL

### Identification of Concealed Randomized Objects through Acquired Response Habits of Stimulus and Word Association

SINCE 1962 several investigators have reported experimental results supporting the claim that Pavel Stepanek of Prague could demonstrate an ESP ability in a simple test situation. In the test used, Stepanek attempted on each trial to say whether the green or the white side

of a card hidden in an opaque cover was presented upward. Two of us<sup>1</sup> summarized the literature dealing with this subject and presented confirmatory evidence obtained in stringently safeguarded experimental conditions.

In 1965 the research with Stepanek was interrupted when it was found that his response of "green" or "white" no longer correlated with the randomized sequences of concealed targets. Later it was discovered that he was associating his responses with the opaque covers in which the cards were hidden. Although unexpected, these association habits were psychologically understandable, for the test procedure was one in which a limited set of covers, randomized out of the subject's sight before each "run", was used over and over. It seemed that the subject, during his repeated calling of these two colours, had shifted his attention away from the cards and had formed habits associating the word "white" or "green" with particular covers.

As long as the covers were exposed to the subject it seemed obvious that the associative habits would be guided by sensory cues. But the circumstances suggested that something more was involved. When new covers were first introduced Stepanek began calling certain ones white and others green, regardless of which sides were presented upward. Because he never turned the stimulus objects over, it was difficult to see how he could have linked the two sides on a sensory basis; we were thus led to consider the hypothesis that he might be using ESP in discriminating among the covers, and we tested it by concealing them inside opaque containers in various conditions.

The hypothesis has been investigated in relation to a selected set of stimuli. Strong tendencies were observed in the first series with these test materials (ten covers, each one containing a card and envelope) in May 1967. So far, they have been used in eighteen experiments. Before the sixth series the number of stimuli was reduced from ten to eight, and before the eighth series it was further reduced to four. In each reduction we kept those covers that had shown the most striking response tendencies. All the work was carried out at the University of Virginia except series 6 and 7, which were carried out in Prague.

To illustrate the findings, we will present the results for cover 15/16 (numbers marking the two sides) for which the subject showed the most striking associative habit. Table 1 shows the distribution of white and green responses for this cover for each series and also the distribution of white and green responses for all the other covers combined. For convenience of comparison these two ratios are converted to percentages of white responses in relation to the trials, and the difference between the ratios of white and green responses is evaluated by the  $\chi^2$  test.

The covers were randomized outside the subject's sight and the prepared stack was placed in front of him. He then responded to the stimuli one after the other, laying them aside into a new stack as he did so. The experimenter recorded his responses and, at the end of the run, the order of the covers. From series 8 onward, the mixing was done on the basis of random numbers by one experimenter and the testing by the other, and each experimenter made an independent record of responses and stimuli. All analyses and statistical evaluations were done by computer.

In series 1 the subject (in sensory contact with the objects for the first time) responded to cover 15/16 by saying white eighty-six times and green only fourteen times. This consistency of choice showed that he somehow recognized this cover as an object regardless of which side was presented upward.

Before series 2 the contents of cover 15/16 were interchanged with those of another cover for which green had been the preponderant choice. The response preferences followed the covers rather than the contents.

Series 3 and 4 were done in parallel with alternation from one condition to the other after every ten runs. Series 3 used the covers exposed as before. In series 4 they were concealed inside larger individual jackets made of two sheets of cardboard cut from manilla file folders and stapled together on three sides. Table 1 shows that the response tendency to cover 15/16 continued in the same way in these two conditions.

Before series 5 new jackets were made with a double thickness of manilla cardboard for each side, stapled together along three sides through ribs of heavy cardboard. The open end of the jacket extended at least 0.5 inch beyond the end of the enclosed cover, and that end always pointed away from the subject. Thus he had no opportunity to see what was inside. In these conditions the same response tendency for cover 15/16 continued.

In series 6 all of the aspects of the stimulus material (cards, envelopes, covers and jackets) were randomized separately before each run. The associative tendency was found to be localized entirely in the covers. In the time available only a series consisting of fifty runs could be completed, but the white preference for cover 15/16 was statistically highly significant.

In series 7, Stepanek was asked to work in the presence of two Czech citizens (a psychologist and a government official) who were strangers to him. The results in this further series of fifty runs were in the same direction though less striking than before. (All other series except 17 and 18 were of 100 runs.)

Series 8 was the first test with only four selected stimuli concealed in four of the double thickness jackets. The results showed the same tendencies present in approximately the same strength after an interruption of 6 months.

Before series 9 the open ends of the four covers were closed up by taping onto them a folded piece of cardboard. This was done because the ends of the covers had become pliable and droopy from repeated use and we wished to make sure that Stepanek was not recognizing them through differences in the degree to which they caused the jackets to bulge. The response tendency to cover 15/16 remained as it was previously. Series 10 was a repetition of the test in the same conditions after an interval of 6 days.

Before series 11 several cotton balls were inserted between the two layers of the jackets on both sides to make the outer layer stand out from the inner one. We wanted to guard against the possibility that any small differences in the shape of the covers might be transmitted through the jackets. The cotton served this purpose by keeping the pressure exerted by the cover from changing the shape of the outer layer of the jacket. As Table 1 shows, Stepanek still significantly favoured the "white" response for cover 15/16.

After thirty runs of series 12 the covers were made equal in weight within a limit of variation of 0.1 g and this

control remained in effect thereafter. The white preference for cover 15/16 was not affected.

In series 13 a third experimenter took the responsibility of observing Stepanek closely on each trial while he was handling the target materials. No evidence was found suggesting that the performance depended in any way on glimpsing an edge or corner of the enclosed covers.

For more objective safeguarding on this point, before series 14 the jacket sides were stapled together throughout their entire length so that short flaps left previously at the open end for convenience of access were fastened down. The first series done with this modification of the jackets did not show significant performance on cover 15/16, but there was a significantly different pattern of response among the other three objects that does not show up in Table 1 ( $P < 2 \times 10^{-3}$ ). (But in series 15 the tendency to call 15/16 white was again present to a significant degree.) Also in series 16 there was a shift in the pattern of response that yielded statistical significance not shown in the table ( $P < 10^{-3}$ ). This was a consequence of the subject's tendency in that session to associate one colour with one side of the cover and the other colour with the other side.

Table 1 shows changes in the strength of the response habit connected with cover 15/16, but these are not the result of changes in experimental conditions involving the imposition of tighter controls. As already stated, statistically significant results were obtained in every case until series 16 (even though in two cases this fact is not revealed in Table 1). Only the last two series failed to yield any statistically significant results, and no changes in controls were introduced in them. Rather, there were special psychological circumstances that could explain the absence of the usual discrimination through associative habits. During most of the runs of series 17 photographers were present making a motion picture film of the testing procedure. Series 18 was carried out in the evening immediately before the subject's departure to return to Czechoslovakia.

The statistical significance shown in Table 1 is not due to the result of a *post hoc* selection of favourable instances, for when the results from all the work carried out during this period are combined the total data are overwhelmingly significant ( $P < 10^{-50}$ ). The experiments already completed will be reported elsewhere in more detail, and the prospects seem good for continuing the investigations.

On whatever basis the habits of object-and-word association were acquired by Stepanek, these patterned responses could not have continued with only slight variations through all the changes in experimental conditions if the habits had been guided solely on a sensory basis. We therefore consider that the results already obtained provide strong evidence for an extrasensory factor in this performance. The findings suggest that these associative habits have become in this subject the means by which ESP impressions are brought to overt

Table 1. PERSISTENCE OF A RESPONSE TENDENCY TOWARD PARTICULAR STIMULI IN DIFFERENT CONDITIONS OF EXPOSURE AND CONCEALMENT

Table 1. PERSISTENCE OF A RESPONSE TENDENCY TOWARD PARTICULAR STIMULI IN DIFFERENT CONDITIONS OF EXPOSURE									
Series	Date	Experimenters taking part	No. of targets	Cover 15/16		Other covers		Chi square Cover 15/16 versus others	P
				Called W/G	Percentage W/(W + G)	Called W/G	Percentage W/(W + G)		
(Section I: covers exposed)									
1	16/V/67	J.G.P.	10	86/14	86	376/524	42	70.8	< 10 <sup>-10</sup>
2	17/V/67	J.G.P.	10	76/24	76	338/562	38	54.8	< 10 <sup>-10</sup>
3	18-19/V/67	J.G.P.	10	74/26	74	351/549	39	45.1	< 10 <sup>-10</sup>
(Section II: covers concealed in opaque jackets)									
4	18-19/ V/67	J.G.P.	10	73/27	73	370/530	41	37.1	< 10 <sup>-8</sup>
5	30-31/ V/67	J.G.P., W.G.R.	10	66/34	66	367/533	41	23.3	< 10 <sup>-8</sup>
6	13/IX/67	J.G.P., J.G.B., N.J., G.L.M.	8	42/8	84	139/211	40	34.6	< 10 <sup>-7</sup>
7	17/IX/67	J.G.P., N.J.	8	33/17	66	165/185	47	6.2	0.02
8	7/II/68	J.G.P., H.H.J.K.	4	77/23	77	108/192	36	50.7	< 10 <sup>-10</sup>
9	8/II/68	J.G.P., H.H.J.K.	4	70/30	70	103/197	34	38.9	< 10 <sup>-8</sup>
10	14/II/68	J.G.P., H.H.J.K.	4	77/23	77	92/208	31	66.0	< 10 <sup>-10</sup>
11	15/II/68	J.G.P., H.H.J.K.	4	64/36	64	111/189	37	22.2	< 10 <sup>-8</sup>
12	16-17/II/68	J.G.P., H.H.J.K.	4	66/34	66	102/198	34	31.5	< 10 <sup>-7</sup>
13	16/II/68	J.G.P., H.H.J.K., I.S.	4	64/36	64	119/181	40	17.9	< 10 <sup>-4</sup>
14	19/II/68	J.G.P., H.H.J.K.	4	44/56	44	117/183	39	0.8	> 0.4
15	20-21/II/68	J.G.P., H.H.J.K.	4	67/33	67	133/168	44	15.6	< 10 <sup>-4</sup>
16	12/III/68	J.G.P., H.H.J.K.	4	56/44	56	136/164	45	3.4	0.07
17	19/III/68	J.G.P., H.H.J.K.	4	26/24	52	77/73	51	0.0	> 0.5
18	19/III/68	J.G.P., H.H.J.K.	4	32/18	64	71/79	47	4.2	0.04



expression, and the high level and reliability of performance suggest that such a habit may be an especially favourable ESP vehicle. Research is needed to see whether other individuals would show similar performance.

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<sup>1</sup> Blom, J. G., and Pratt, J. G., *J. Amer. Soc. Psychical Res.*, **62**, 28 (1968).

The following is an extract from the report of one of two referees. The other referee recommended that the communication should not be published.

I consider that the facts with which this deals deserve to be brought before a wider scientific public than would be attainable if they were to appear only in a specialist journal.

The one point on which criticism could alight is that the subject himself handles the target-packets the content of which he is required to guess. Inevitably this gives rise to the suspicion that the effects may be due to certain subtle cues connected with the differential warping of the target-materials. It seems, however, that the effect has stood up under such a variety of conditions (see especially series 11, fourteenth paragraph) that such a possibility can be ruled out. I would have been still happier if the outer jackets had been made of rigid materials rather than the double-thickness manilla file folder card mentioned in the ninth paragraph, but I cannot fault the authors' claim to have effectively eliminated all normal counter-hypotheses. Accordingly, I see no way of avoiding the conclusion that, in the situation described, a particular verbal response was being elicited by a concealed stimulus-object even though this object could not have been recognized by the use of any known sensory mechanism. The general interest and importance of such a conclusion speaks for itself.

## Investigations of the Inks used in Writing the Dead Sea Scrolls

FUNERAL texts written on stones found inside a grave in the cemetery at Qumran have recently been described<sup>1</sup>. This discovery necessitated an investigation of the composition of the inks used by the Qumran community, chiefly because the ink on the stones had faded and could only be seen with the aid of ultraviolet fluorescent lamps, while photographs taken with ultraviolet lighting and infrared film were not satisfactory.

Brief reports on the inks used to write the Dead Sea Scrolls have been published<sup>2,3</sup>, but most of the tests to determine the nature of these inks, carried out nearly 20 years ago, have not been published. I report here work carried out by Dr H. J. Plenderleith, formerly keeper of the Research Laboratory of the British Museum, on the Dead Sea Scrolls, and by Professor D. Vofsi, of the Weizmann Institute of Science, on the Qumran funeral texts.

Plenderleith's work confirms published reports that the inks had a carbon base; reference is also made to ink with an iron base. Professor Yigael Yadin has pointed out that a metal based ink was apparently used for writing the *Apocryphon of Genesis* scroll<sup>4</sup>. This was, however, acquired by Yadin and unrolled several years later so that it could not be the major scroll on which iron ink was found, as mentioned in the report by Plenderleith. We have been unable to ascertain who conducted these tests on the six scrolls then extant.

Wherever writing was found, the ink was quite black and showed no tendency to turn rust coloured. Twelve separate fragments bearing vestiges of script were collected and tested with potassium ferricyanide—a sensitive method of detecting the presence of iron—but results were all negative. Bleaching agents seemed to have no effect on the writing and, there being no loss of intensity, the conclusion was that all the writing was done with carbon ink. This has been taken by some archaeologists as a criterion for dating, but iron as well as carbon inks were available before the Christian era; iron had been used, at least sporadically, ever since the invention of tanning. Iron occurs universally, and has only to be present in solution with tannins for a writing ink to be formed, so that the fact that some of the main scrolls were written in iron ink is no indication of their age. It is also fair to claim, because the writing is legible, that it could not have been done when the skins were old and absorbent—there can be no doubt that the ink is as old as the skins.

While I accept that the presence of carbon or iron ink is no criterion for dating the Dead Sea Scrolls, it should be noted that the oldest known specimen of an iron-based ink dates from the seventh century AD (ref. 5). It is generally accepted that the Dead Sea Scrolls were written during the two centuries before the present era and in the first half of the first century AD, and so the presence of an iron based ink at that time, while not refuting the dating of the documents, could have a bearing on the work on Qumran texts.

In 1954 Plenderleith used a spectrograph to examine two samples from Qumran. The first was a mass of white crystals with a spectrum indicating a high content of calcium. Chemical analysis showed sulphate to be present in quantity and a heat test showed the presence of water crystallization. The sample was therefore a residue of gypsum and had no particular association with ink. The second sample also contained calcium, but in association with traces of copper, tin, lead, silver, iron and manganese. The chief constituent was carbon. The sample was the residue of a carbon ink, no doubt contaminated with the corrosion products of a metal (bronze) inkwell.

Three inkwells, one bronze and two clay, were found during excavations at Qumran by Pere Roland de Vaux of the Ecole Biblique, and another clay inkwell was found later during my own excavations in conjunction with the Department of Antiquities of the Government of Jordan. An analysis of the ink residue in this specimen is being prepared by Dr George Adler, of the Brookhaven National Laboratories, New York. A preliminary examination has shown that this ink does not contain an appreciable amount of iron, for it did not fluoresce when tested with a copper X-ray tube.

The results of these tests suggested that a carbon ink should be used in any subsequent experimental work. The stones used were collected in Qumran, in gloved